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AP-42, Fifth Edition, Volume I
Chapter 5: Petroleum Industry

Explanation of File Formats

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Chapter 5: Frequently Asked Questions (FAQ)

5.0 Introduction to Petroleum Industry

5.1 Petroleum Refining
- Final Section - January 1995 (PDF 207K)

5.2 Transportation and Marketing of Petroleum Liquids
- Draft - December 1995 (ZIP 38K)
- Final Section - January 1995 (PDF 322K)
- Related EIIP Documents (PDF 200K)

5.3 Natural Gas Processing
- Final Section - Supplement A, January 1995 (PDF 80K)

Related Emission Factor Documents

Protocol for Equipment Leak Emission Estimates
- Main Document - (EPA 453/R-95-017), November 1995 (PDF 1.4M)
- Appendices - (EPA 453/R-95-017), November 1995 (PDF 880K)
- Related Info.

AP-42 Emission Factors by Chapter

5.2 FINAL SECTION

5.2 Transportation And Marketing Of Petroleum Liquids[1-3]

5.2.1 General

The transportation and marketing of petroleum liquids involve many distinct operations, each of which represents a potential source of evaporation loss. Crude oil is transported from production operations to a refinery by tankers, barges, rail tank cars, tank trucks, and pipelines. Refined petroleum products are conveyed to fuel marketing terminals and petrochemical industries by these same modes. From the fuel marketing terminals, the fuels are delivered by tank trucks to service stations, commercial accounts, and local bulk storage plants. The final destination for gasoline is usually a motor vehicle gasoline tank. Similar distribution paths exist for fuel oils and other petroleum products. A general depiction of these activities is shown in Figure 5.2-1.

5.2.2 Emissions And Controls

Evaporative emissions from the transportation and marketing of petroleum liquids may be considered, by storage equipment and mode of transportation used, in four categories:

1. Rail tank cars, tank trucks, and marine vessels: loading, transit, and ballasting losses.
2. Service stations: bulk fuel drop losses and underground tank breathing losses.
3. Motor vehicle tanks: refueling losses.
4. Large storage tanks: breathing, working, and standing storage losses. (See Chapter 7, "Liquid Storage Tanks".)

Evaporative and exhaust emissions are also associated with motor vehicle operation, and these topics are discussed in AP-42 *Volume II: Mobile Sources*.

5.2.2.1 Rail Tank Cars, Tank Trucks, And Marine Vessels -
Emissions from these sources are from loading losses, ballasting losses, and transit losses.

5.2.2.1.1 Loading Losses -
Loading losses are the primary source of evaporative emissions from rail tank car, tank truck, and marine vessel operations. Loading losses occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of (1) vapors formed in the empty tank by evaporation of residual product from previous loads, (2) vapors transferred to the tank in vapor balance systems as product is being unloaded, and (3) vapors generated in the tank as the new product is being loaded. The quantity of evaporative losses from loading operations is, therefore, a function of the following parameters:

- Physical and chemical characteristics of the previous cargo;
- Method of unloading the previous cargo;
- Operations to transport the empty carrier to a loading terminal;
- Method of loading the new cargo; and
- Physical and chemical characteristics of the new cargo.

The principal methods of cargo carrier loading are illustrated in Figure 5.2-2, Figure 5.2-3, and Figure 5.2-4. In the splash loading method, the fill pipe dispensing the cargo is lowered only part way into the cargo tank. Significant turbulence and vapor/liquid contact occur during the splash

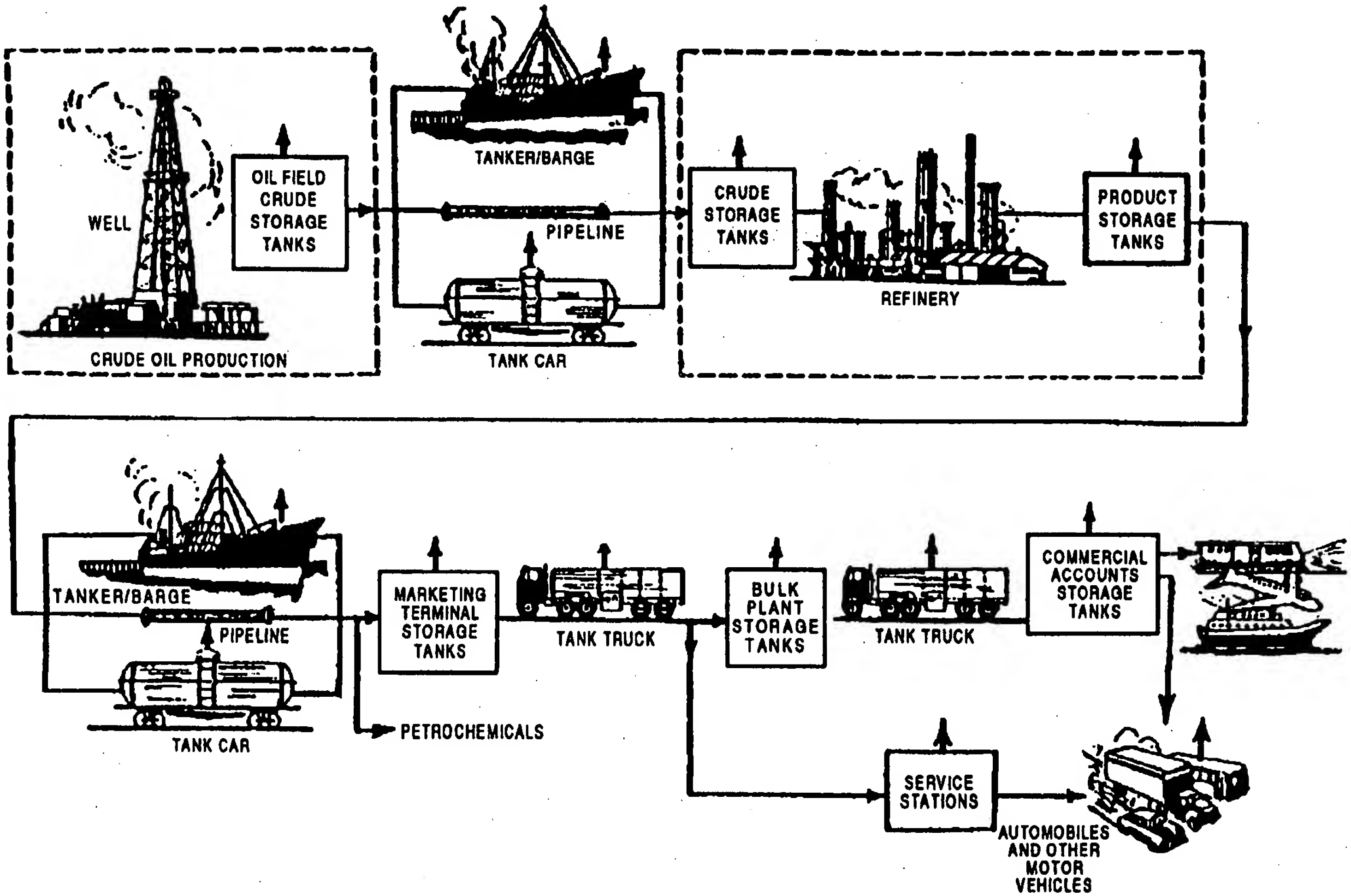

Figure 5.2-1. Flow sheet of petroleum production, refining, and distribution systems.
(Points of organic emissions are indicated by vertical arrows.)

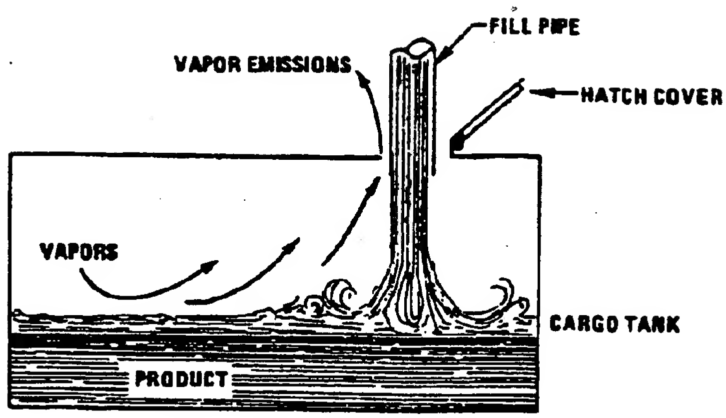

Figure 5.2-2. Splash loading method.

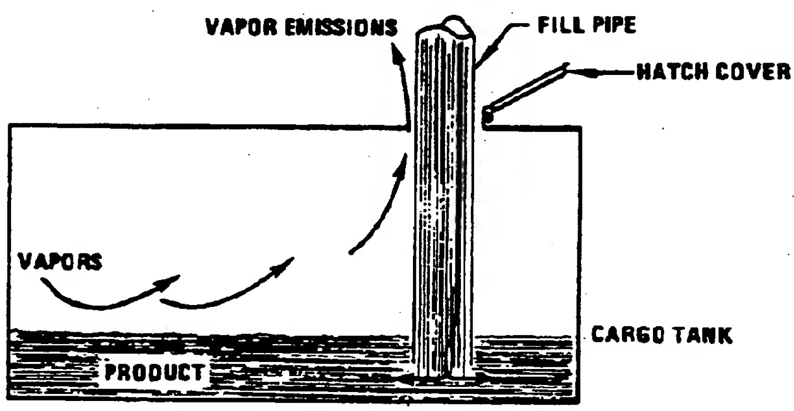

Figure 5.2-3. Submerged fill pipe.

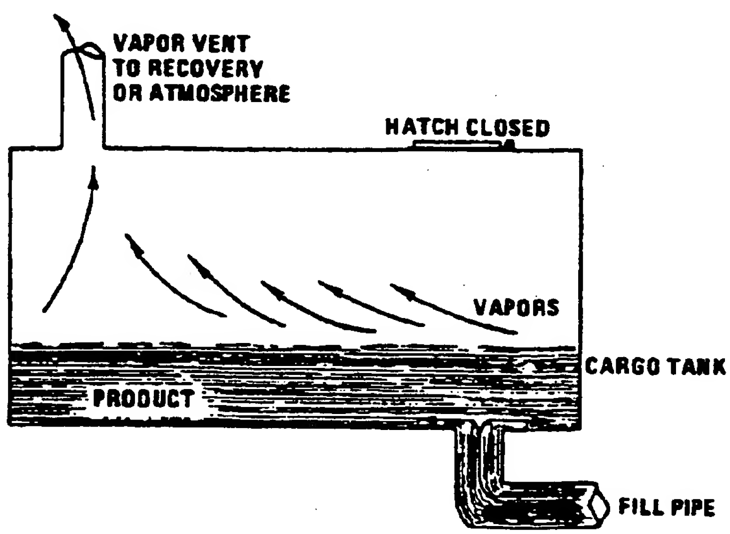

Figure 5.2-4. Bottom loading.

loading operation, resulting in high levels of vapor generation and loss. If the turbulence is great enough, liquid droplets will be entrained in the vented vapors.

A second method of loading is submerged loading. Two types are the submerged fill pipe method and the bottom loading method. In the submerged fill pipe method, the fill pipe extends almost to the bottom of the cargo tank. In the bottom loading method, a permanent fill pipe is attached to the cargo tank bottom. During most of submerged loading by both methods, the fill pipe opening is below the liquid surface level. Liquid turbulence is controlled significantly during submerged loading, resulting in much lower vapor generation than encountered during splash loading.

The recent loading history of a cargo carrier is just as important a factor in loading losses as the method of loading. If the carrier has carried a nonvolatile liquid such as fuel oil, or has just been cleaned, it will contain vapor-free air. If it has just carried gasoline and has not been vented, the air in the carrier tank will contain volatile organic vapors, which will be expelled during the loading operation along with newly generated vapors.

Cargo carriers are sometimes designated to transport only one product, and in such cases are practicing "dedicated service". Dedicated gasoline cargo tanks return to a loading terminal containing air fully or partially saturated with vapor from the previous load. Cargo tanks may also be "switch loaded" with various products, so that a nonvolatile product being loaded may expel the vapors remaining from a previous load of a volatile product such as gasoline. These circumstances vary with the type of cargo tank and with the ownership of the carrier, the petroleum liquids being transported, geographic location, and season of the year.

One control measure for vapors displaced during liquid loading is called "vapor balance service", in which the cargo tank retrieves the vapors displaced during product unloading at bulk plants or service stations and transports the vapors back to the loading terminal. Figure 5.2-5 shows a tank truck in vapor balance service filling a service station underground tank and taking on displaced gasoline vapors for return to the terminal. A cargo tank returning to a bulk terminal in vapor balance service normally is saturated with organic vapors, and the presence of these vapors at the start of submerged loading of the tanker truck results in greater loading losses than encountered during nonvapor balance, or "normal", service. Vapor balance service is usually not practiced with marine vessels, although some vessels practice emission control by means of vapor transfer within their own cargo tanks during ballasting operations, discussed below.

Emissions from loading petroleum liquid can be estimated (with a probable error of ±30 percent)[4] using the following expression:

$$L_L = 12.46 \frac{SPM}{T} \tag{1}$$

where:

L_L = loading loss, pounds per 1000 gallons ($lb/10^3$ gal) of liquid loaded
S = a saturation factor (see Table 5.2-1)
P = true vapor pressure of liquid loaded, pounds per square inch absolute (psia) (see Figure 7.1-5, Figure 7.1-6, and Table 7.1-2)
M = molecular weight of vapors, pounds per pound-mole (lb/lb-mole) (see Table 7.1-2)
T = temperature of bulk liquid loaded, °R (°F + 460)

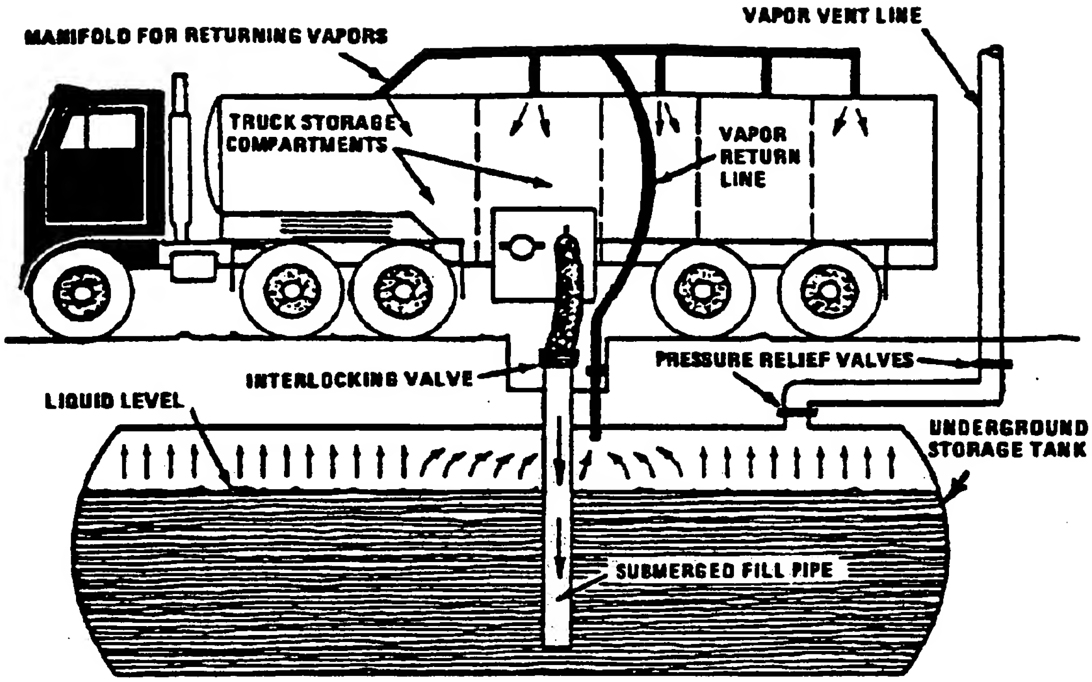

Figure 5.2-5. Tank truck unloading into a service station underground storage tank and practicing "vapor balance" form of emission control.

Table 5.2-1. SATURATION (S) FACTORS FOR CALCULATING PETROLEUM LIQUID LOADING LOSSES

Cargo Carrier	Mode Of Operation	S Factor
Tank trucks and rail tank cars	Submerged loading of a clean cargo tank	0.50
	Submerged loading: dedicated normal service	0.60
	Submerged loading: dedicated vapor balance service	1.00
	Splash loading of a clean cargo tank	1.45
	Splash loading: dedicated normal service	1.45
	Splash loading: dedicated vapor balance service	1.00
Marine vessels[a]	Submerged loading: ships	0.2
	Submerged loading: barges	0.5

[a] For products other than gasoline and crude oil. For marine loading of gasoline, use factors from Table 5.2-2. For marine loading of crude oil, use Equations 2 and 3 and Table 5.2-3.

The saturation factor, S, represents the expelled vapor's fractional approach to saturation, and it accounts for the variations observed in emission rates from the different unloading and loading methods. Table 5.2-1 lists suggested saturation factors.

Emissions from controlled loading operations can be calculated by multiplying the uncontrolled emission rate calculated in Equation 1 by an overall reduction efficiency term:

$$\left(1 - \frac{\text{eff}}{100}\right)$$

The overall reduction efficiency should account for the capture efficiency of the collection system as well as both the control efficiency and any downtime of the control device. Measures to reduce loading emissions include selection of alternate loading methods and application of vapor recovery equipment. The latter captures organic vapors displaced during loading operations and recovers the vapors by the use of refrigeration, absorption, adsorption, and/or compression. The recovered product is piped back to storage. Vapors can also be controlled through combustion in a thermal oxidation unit, with no product recovery. Figure 5.2-6 demonstrates the recovery of gasoline vapors from tank trucks during loading operations at bulk terminals. Control efficiencies for the recovery units range from 90 to over 99 percent, depending on both the nature of the vapors and the type of control equipment used.[5-6] However, only 70 to 90 percent of the displaced vapors reach the control device, because of leakage from both the tank truck and collection system.[6] The collection efficiency should be assumed to be 90 percent for tanker trucks required to pass an annual leak test. Otherwise, 70 percent should be assumed.

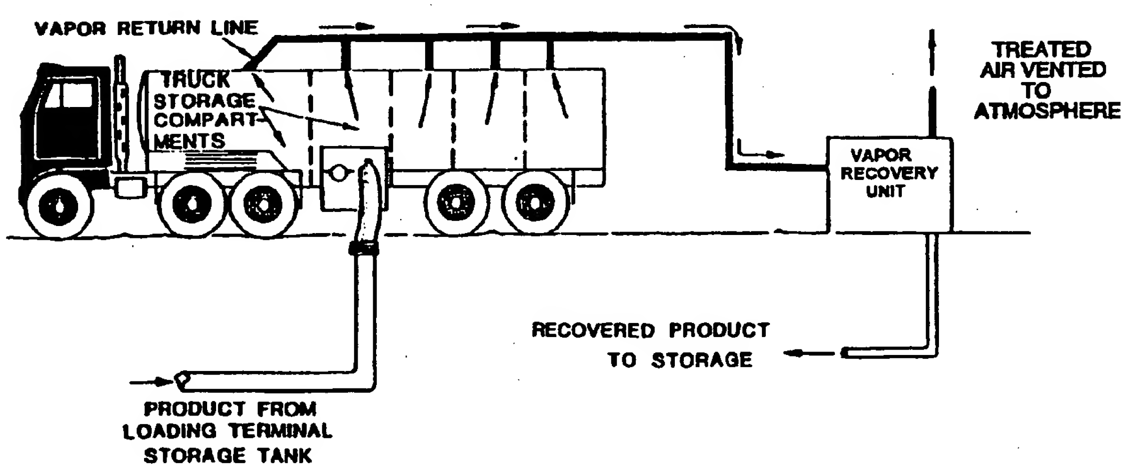

Figure 5.2-6. Tank truck loading with vapor recovery.

Sample Calculation -

Loading losses (L_L) from a gasoline tank truck in dedicated vapor balance service and practicing vapor recovery would be calculated as follows, using Equation 1:

Design basis -

Cargo tank volume is 8000 gal
Gasoline Reid vapor pressure (RVP) is 9 psia
Product temperature is 80°F
Vapor recovery efficiency is 95 percent
Vapor collection efficiency is 90 percent (for vessels passing annual leak test)

Loading loss equation -

$$L_L = 12.46 \frac{SPM}{T} \left(1 - \frac{eff}{100}\right)$$

where:

S = saturation factor (see Table 5.2-1) - 1.00
P = true vapor pressure of gasoline (see Figure 7.1-6) = 6.6 psia
M = molecular weight of gasoline vapors (see Table 7.1-2) = 66
T = temperature of gasoline = 540°R
eff = overall reduction efficiency (95 percent control x 90 percent collection) = 85 percent

$$L_L = 12.46 \frac{(1.00)(6.6)(66)}{540} \left(1 - \frac{85}{100}\right)$$

$$= 1.5 \ \mathrm{lb}/10^3 \mathrm{gal}$$

Total loading losses are:

$$(1.5 \ \mathrm{lb}/10^3 \ \mathrm{gal})(8.0 \times 10^3 \ \mathrm{gal}) = 12 \ \mathrm{pounds} \ (\mathrm{lb})$$

Measurements of gasoline loading losses from ships and barges have led to the development of emission factors for these specific loading operations.[7] These factors are presented in Table 5.2-2 and should be used instead of Equation 1 for gasoline loading operations at marine terminals. Factors are expressed in units of milligrams per liter (mg/L) and pounds per 1000 gallons (lb/10^3 gal).

Table 5.2-2 (Metric And English Units). VOLATILE ORGANIC COMPOUND (VOC) EMISSION FACTORS FOR GASOLINE LOADING OPERATIONS AT MARINE TERMINALS[a]

Vessel Tank Condition	Previous Cargo	Ships/Ocean Barges[b]		Barges[b]	
		mg/L Transferred	$lb/10^3$ gal Transferred	mg/L Transferred	$lb/10^3$ gal Transferred
Uncleaned	Volatile[c]	315	2.6	465	3.9
Ballasted	Volatile	205	1.7	—[d]	—[d]
Cleaned	Volatile	180	1.5	ND	ND
Gas-freed	Volatile	85	0.7	ND	ND
Any condition	Nonvolatile	85	0.7	ND	ND
Gas-freed	Any cargo	ND	ND	245	2.0
Typical overall situation[e]	Any cargo	215	1.8	410	3.4

[a] References 2,8. Factors are for both VOC emissions (which excludes methane and ethane) and total organic emissions, because methane and ethane have been found to constitute a negligible weight fraction of the evaporative emissions from gasoline. ND = no data.
[b] Ocean barges (tank compartment depth about 12.2 m [40 ft]) exhibit emission levels similar to tank ships. Shallow draft barges (compartment depth 3.0 to 3.7 m [10 to 12 ft]) exhibit higher emission levels.
[c] Volatile cargoes are those with a true vapor pressure greater than 10 kilopascals (kPa) (1.5 psia).
[d] Barges are usually not ballasted.
[e] Based on observation that 41% of tested ship compartments were uncleaned, 11% ballasted, 24% cleaned, and 24% gas-freed. For barges, 76% were uncleaned.

In addition to Equation 1, which estimates emissions from the loading of petroleum liquids, Equation 2 has been developed specifically for estimating emissions from the loading of crude oil into ships and ocean barges:

$$C_L = C_A + C_G \tag{2}$$

where:

C_L = total loading loss, $lb/10^3$ gal of crude oil loaded
C_A = arrival emission factor, contributed by vapors in the empty tank compartment before loading, $lb/10^3$ gal loaded (see Note below)
C_G = generated emission factor, contributed by evaporation during loading, $lb/10^3$ gal loaded

Note: Values of C_A for various cargo tank conditions are listed in Table 5.2-3.

5.2-3 (English Units). AVERAGE ARRIVAL EMISSION FACTORS, C_A, FOR CRUDE OIL LOADING EMISSION EQUATION[a]

Ship/Ocean Barge Tank Condition	Previous Cargo	Arrival Emission Factor, $lb/10^3$ gal
Uncleaned	Volatile[b]	0.86
Ballasted	Volatile	0.46
Cleaned or gas-freed	Volatile	0.33
Any condition	Nonvolatile	0.33

[a] Arrival emission factors (C_A) to be added to generated emission factors (C_G) calculated in Equation 3 to produce total crude oil loading loss (C_L). Factors are for total organic compounds; VOC emission factors average about 15% lower, because VOC does not include methane or ethane.

[b] Volatile cargoes are those with a true vapor pressure greater than 10 kPa (1.5 psia).

This equation was developed empirically from test measurements of several vessel compartments.[7] The quantity C_G can be calculated using Equation 3:

$$C_G = 1.84\ (0.44\ P - 0.42)\ \frac{M\,G}{T} \tag{3}$$

where:

P = true vapor pressure of loaded crude oil, psia (see Figure 7.1-5 and Table 7.1-2)
M = molecular weight of vapors, lb/lb-mole (see Table 7.1-2)
G = vapor growth factor = 1.02 (dimensionless)
T = temperature of vapors, °R (°F + 460)

Emission factors derived from Equation 3 and Table 5.2-3 represent total organic compounds. Volatile organic compound (VOC) emission factors (which exclude methane and ethane because they are exempted from the regulatory definition of "VOC") for crude oil vapors have been found to range from approximately 55 to 100 weight percent of these total organic factors. When specific vapor composition information is not available, the VOC emission factor can be estimated by taking 85 percent of the total organic factor.[3]

5.2.2.1.2 Ballasting Losses -

Ballasting operations are a major source of evaporative emissions associated with the unloading of petroleum liquids at marine terminals. It is common practice to load several cargo tank compartments with sea water after the cargo has been unloaded. This water, termed "ballast", improves the stability of the empty tanker during the subsequent voyage. Although ballasting practices vary, individual cargo tanks are ballasted typically about 80 percent, and the total vessel 15 to 40 percent, of capacity. Ballasting emissions occur as vapor-laden air in the "empty" cargo tank is displaced to the atmosphere by ballast water being pumped into the tank. Upon arrival at a loading port, the ballast water is pumped from the cargo tanks before the new cargo is loaded. The ballasting of cargo tanks reduces the quantity of vapors returning in the empty tank, thereby reducing the quantity of vapors emitted during subsequent tanker loading. Regulations administered by the U. S. Coast Guard require that, at marine terminals located in ozone nonattainment areas, large tankers with crude oil washing systems contain the organic vapors from ballasting.[9] This is accomplished principally by displacing the vapors during

ballasting into a cargo tank being simultaneously unloaded. In other areas, marine vessels emit organic vapors directly to the atmosphere.

Equation 4 has been developed from test data to calculate the ballasting emissions from crude oil ships and ocean barges[7]:

$$L_B = 0.31 + 0.20\,P + 0.01\,PU_A \qquad (4)$$

where:

L_B = ballasting emission factor, lb/10^3 gal of ballast water
P = true vapor pressure of discharged crude oil, psia (see Figure 7.1-5 and Table 7.1-2)
U_A = arrival cargo true ullage, before dockside discharge, measured from the deck, feet; (the term "ullage" here refers to the distance between the cargo surface level and the deck level)

Table 5.2-4 lists average total organic emission factors for ballasting into uncleaned crude oil cargo compartments. The first category applies to "full" compartments wherein the crude oil true ullage just before cargo discharge is less than 1.5 meters (m) (5 ft). The second category applies to lightered, or short-loaded, compartments (part of cargo previously discharged, or original load a partial fill), with an arrival true ullage greater than 1.5 m (5 ft). It should be remembered that these tabulated emission factors are examples only, based on average conditions, to be used when crude oil vapor pressure is unknown. Equation 4 should be used when information about crude oil vapor pressure and cargo compartment condition is available. The following sample calculation illustrates the use of Equation 4.

5.2-4 (Metric And English Units). TOTAL ORGANIC EMISSION FACTORS FOR CRUDE OIL BALLASTING[a]

	Average Emission Factors			
	By Category		Typical Overall[b]	
Compartment Condition Before Cargo Discharge	mg/L Ballast Water	lb/10^3 gal Ballast Water	mg/L Ballast Water	lb/10^3 gal Ballast Water
Fully loaded[c]	111	0.9	129	1.1
Lightered or previously short loaded[d]	171	1.4		

[a] Assumes crude oil temperature of 16°C (60°F) and RVP of 34 kPa (5 psia). VOC emission factors average about 85% of these total organic factors, because VOCs do not include methane or ethane.
[b] Based on observation that 70% of tested compartments had been fully loaded before ballasting. May not represent average vessel practices.
[c] Assumed typical arrival ullage of 0.6 m (2 ft).
[d] Assumed typical arrival ullage of 6.1 m (20 ft).

Sample Calculation -

Ballasting emissions from a crude oil cargo ship would be calculated as follows, using Equation 4:

Design basis -

Vessel and cargo description:	80,000 dead-weight-ton tanker, crude oil capacity 500,000 barrels (bbl); 20 percent of the cargo capacity is filled with ballast water after cargo discharge. The crude oil has an RVP of 6 psia and is discharged at 75°F.
Compartment conditions:	70 percent of the ballast water is loaded into compartments that had been fully loaded to 2 ft ullage, and 30 percent is loaded into compartments that had been lightered to 15 ft ullage before arrival at dockside.

Ballasting emission equation -

$$L_B = 0.31 + 0.20\ P + 0.01\ PU_A$$

where:

P = true vapor pressure of crude oil (see Figure 7.1-5)
= 4.6 psia

U_A = true cargo ullage for the full compartments = 2 ft, and true cargo ullage for the lightered compartments = 15 ft

$$L_B = 0.70\ [0.31 + (0.20)\ (4.6) + (0.01)\ (4.6)\ (2)] + 0.30\ [0.31 + (0.20)\ (4.6) + (0.01)\ (4.6)\ (15)]$$

$$= 1.5\ lb/10^3\ gal$$

Total ballasting emissions are:

$$(1.5\ lb/10^3\ gal)\ (0.20)\ (500,000\ bbl)\ (42\ gal/bbl) = 6,300\ lb$$

Since VOC emissions average about 85 percent of these total organic emissions, emissions of VOCs are about: (0.85)(6,300 lb) = 5,360 lb

5.2.2.1.3 Transit Losses -

In addition to loading and ballasting losses, losses occur while the cargo is in transit. Transit losses are similar in many ways to breathing losses associated with petroleum storage (see Section 7.1, "Organic Liquid Storage Tanks"). Experimental tests on ships and barges[4] have indicated that transit losses can be calculated using Equation 5:

$$L_T = 0.1\ PW \tag{5}$$

where:

L_T = transit loss from ships and barges, lb/week-10^3 gal transported
P = true vapor pressure of the transported liquid, psia (see Figure 7.1-5, Figure 7.1-6, and Table 7.1-2)
W = density of the condensed vapors, lb/gal (see Table 7.1-2)

Emissions from gasoline truck cargo tanks during transit have been studied by a combination of theoretical and experimental techniques, and typical emission values are presented in Table 5.2-5.[10-11] Emissions depend on the extent of venting from the cargo tank during transit, which in turn depends on the vapor tightness of the tank, the pressure relief valve settings, the pressure in the tank at the start of the trip, the vapor pressure of the fuel being transported, and the degree of fuel vapor saturation of the space in the tank. The emissions are not directly proportional to the time spent in transit. If the vapor leakage rate of the tank increases, emissions increase up to a point, and then the rate changes as other determining factors take over. Truck tanks in dedicated vapor balance service usually contain saturated vapors, and this leads to lower emissions during transit because no additional fuel evaporates to raise the pressure in the tank to cause venting. Table 5.2-5 lists "typical" values for transit emissions and "extreme" values that could occur in the unlikely event that all determining factors combined to cause maximum emissions.

Table 5.2-5 (Metric And English Units). TOTAL UNCONTROLLED ORGANIC EMISSION FACTORS FOR PETROLEUM LIQUID RAIL TANK CARS AND TANK TRUCKS

Emission Source	Gasoline[a]	Crude Oil[b]	Jet Naphtha (JP-4)	Jet Kerosene	Distillate Oil No. 2	Residual Oil No. 6
Loading operations[c]						
Submerged loading - Dedicated normal service[d]						
mg/L transferred	590	240	180	1.9	1.7	0.01
lb/10^3 gal transferred	5	2	1.5	0.016	0.014	0.0001
Submerged loading - Vapor balance service[d]						
mg/L transferred	980	400	300	—[e]	—[e]	—[e]
lb/10^3 gal transferred	8	3	2.5	—[e]	—[e]	—[e]
Splash loading - Dedicated normal service						
mg/L transferred	1,430	580	430	5	4	0.03
lb/10^3 gal transferred	12	5	4	0.04	0.03	0.0003
Splash loading - Vapor balance service						
mg/L transferred	980	400	300	—[e]	—[e]	—[e]
lb/10^3 gal transferred	8	3	2.5	—[e]	—[e]	—[e]

Table 5.2-5 (cont.).

Emission Source	Gasoline[a]	Crude Oil[b]	Jet Naphtha (JP-4)	Jet Kerosene	Distillate Oil No. 2	Residual Oil No. 6
Transit losses						
Loaded with product						
mg/L transported						
Typical	0 - 1.0	ND	ND	ND	ND	ND
Extreme	0 - 9.0	ND	ND	ND	ND	ND
lb/10^3 gal transported						
Typical	0 - 0.01	ND	ND	ND	ND	ND
Extreme	0 - 0.08	ND	ND	ND	ND	ND
Return with vapor						
mg/L transported						
Typical	0 - 13.0	ND	ND	ND	ND	ND
Extreme	0 - 44.0	ND	ND	ND	ND	ND
lb/10^3 gal transported						
Typical	0 - 0.11	ND	ND	ND	ND	ND
Extreme	0 - 0.37	ND	ND	ND	ND	ND

[a] Reference 2. Gasoline factors represent emissions of VOC as well as total organics, because methane and ethane constitute a negligible weight fraction of the evaporative emissions from gasoline. VOC factors for crude oil can be assumed to be 15% lower than the total organic factors, to account for the methane and ethane content of crude oil evaporative emissions. All other products should be assumed to have VOC factors equal to total organics. The example gasoline has an RVP of 69 kPa (10 psia). ND = no data.

[b] The example crude oil has an RVP of 34 kPa (5 psia).

[c] Loading emission factors are calculated using Equation 1 for a dispensed product temperature of 16°C (60°F).

[d] Reference 2.

[e] Not normally used.

In the absence of specific inputs for Equations 1 through 5, the typical evaporative emission factors presented in Tables 5.2-5 and 5.2-6 should be used. It should be noted that, although the crude oil used to calculate the emission values presented in these tables has an RVP of 5, the RVP of crude oils can range from less than 1 up to 10. Similarly, the RVP of gasolines ranges from 7 to 13. In areas where loading and transportation sources are major factors affecting air quality, it is advisable to obtain the necessary parameters and to calculate emission estimates using Equations 1 through 5.

5.2.2.2 Service Stations -

Another major source of evaporative emissions is the filling of underground gasoline storage tanks at service stations. Gasoline is usually delivered to service stations in 30,000-liter (8,000-gal) tank trucks or smaller account trucks. Emissions are generated when gasoline vapors in the

Table 5.2-6 (Metric And English Units). TOTAL ORGANIC EMISSION FACTORS FOR PETROLEUM MARINE VESSEL SOURCES[a]

Emission Source	Gasoline[b]	Crude Oil[c]	Jet Naphtha (JP-4)	Jet Kerosene	Distillate Oil No. 2	Residual Oil No. 6
Loading operations						
Ships/ocean barges						
mg/L transferred	—[d]	73	60	0.63	0.55	0.004
lb/10^3 gal transferred	—[d]	0.61	0.50	0.005	0.005	0.00004
Barges						
mg/L transferred	—[d]	120	150	1.60	1.40	0.011
lb/10^3 gal transferred	—[d]	1.0	1.2	0.013	0.012	0.00009
Tanker ballasting						
mg/L ballast water	100	—[e]	ND	ND	ND	ND
lb/10^3 gal ballast water	0.8	—[e]	ND	ND	ND	ND
Transit						
mg/week-L transported	320	150	84	0.60	0.54	0.003
lb/week-10^3 gal transported	2.7	1.3	0.7	0.005	0.005	0.00003

[a] Factors are for a dispensed product of 16°C (60°F). ND = no data.
[b] Factors represent VOC as well as total organic emissions, because methane and ethane constitute a negligible fraction of gasoline evaporative emissions. All products other than crude oil can be assumed to have VOC factors equal to total organic factors. The example gasoline has an RVP of 69 kPa (10 psia).
[c] VOC emission factors for a typical crude oil are 15% lower than the total organic factors shown, in order to account for methane and ethane. The example crude oil has an RVP of 34 kPa (5 psia).
[d] See Table 5.2-2 for these factors.
[e] See Table 5.2-4 for these factors.

underground storage tank are displaced to the atmosphere by the gasoline being loaded into the tank. As with other loading losses, the quantity of loss in service station tank filling depends on several variables, including the method and rate of filling, the tank configuration, and the gasoline temperature, vapor pressure and composition. An average emission rate for submerged filling is 880 mg/L (7.3 lb/1000 gal) of transferred gasoline, and the rate for splash filling is 1380 mg/L (11.5 lb/1000 gal) transferred gasoline (see Table 5.2-7).[5]

Emissions from underground tank filling operations at service stations can be reduced by the use of a vapor balance system such as in Figure 5.2-5 (termed Stage I vapor control). The vapor balance system employs a hose that returns gasoline vapors displaced from the underground tank to the tank truck cargo compartments being emptied. The control efficiency of the balance system ranges from 93 to 100 percent. Organic emissions from underground tank filling operations at a service station employing a vapor balance system and submerged filling are not expected to exceed 40 mg/L (0.3 lb/1000 gal) of transferred gasoline.

Table 5.2-7 (Metric And English Units). EVAPORATIVE EMISSIONS FROM GASOLINE SERVICE STATION OPERATIONS[a]

Emission Source	Emission Rate: mg/L Throughput	Emission Rate: lb/10^3 gal Throughput
Filling underground tank (Stage I)		
Submerged filling	880	7.3
Splash filling	1,380	11.5
Balanced submerged filling	40	0.3
Underground tank breathing and emptying[b]	120	1.0
Vehicle refueling operations (Stage II)		
Displacement losses (uncontrolled)[c]	1,320	11.0
Displacement losses (controlled)	132	1.1
Spillage	80	0.7

[a] Factors are for VOC as well as total organic emissions, because of the methane and ethane content of gasoline evaporative emissions is negligible.
[b] Includes any vapor loss between underground tank and gas pump.
[c] Based on Equation 6, using average conditions.

A second source of vapor emissions from service stations is underground tank breathing. Breathing losses occur daily and are attributable to gasoline evaporation and barometric pressure changes. The frequency with which gasoline is withdrawn from the tank, allowing fresh air to enter to enhance evaporation, also has a major effect on the quantity of these emissions. An average breathing emission rate is 120 mg/L (1.0 lb/1000 gal) of throughput.

5.2.2.3 Motor Vehicle Refueling -

Service station vehicle refueling activity also produces evaporative emissions. Vehicle refueling emissions come from vapors displaced from the automobile tank by dispensed gasoline and from spillage. The quantity of displaced vapors depends on gasoline temperature, auto tank temperature, gasoline RVP, and dispensing rate. Equation 6 can be used to estimate uncontrolled displacement losses from vehicle refueling for a particular set of conditions.[13]

$$E_R = 264.2\ [(-5.909) - 0.0949\ (\Delta T) + 0.0884\ (T_D) + 0.485\ (RVP)] \tag{6}$$

where:

E_R = refueling emissions, mg/L
ΔT = difference between temperature of fuel in vehicle tank and temperature of dispensed fuel, °F
T_D = temperature of dispensed fuel, °F
RVP = Reid vapor pressure, psia

Note that this equation and the spillage loss factor are incorporated into the *MOBILE* model. The *MOBILE* model allows for disabling of this calculation if it is desired to include these emissions in the stationary area source portion of an inventory rather than in the mobile source portion. It is estimated that the uncontrolled emissions from vapors displaced during vehicle refueling average 1320 mg/L (11.0 lb/1000 gal) of dispensed gasoline.[5,12]

Spillage loss is made up of contributions from prefill and postfill nozzle drip and from spit-back and overflow from the vehicles's fuel tank filler pipe during filling. The amount of spillage loss can depend on several variables, including service station business characteristics, tank configuration, and operator techniques. An average spillage loss is 80 mg/L (0.7 lb/1000 gal) of dispensed gasoline.[5,12]

Control methods for vehicle refueling emissions are based on conveying the vapors displaced from the vehicle fuel tank to the underground storage tank vapor space through the use of a special hose and nozzle, as depicted in Figure 5.2-7 (termed Stage II vapor control). In "balance" vapor control systems, the vapors are conveyed by natural pressure differentials established during refueling. In "vacuum assist" systems, the conveyance of vapors from the auto fuel tank to the underground storage tank is assisted by a vacuum pump. Tests on a few systems have indicated overall systems control efficiencies in the range of 88 to 92 percent.[5,12] When inventorying these emissions as an area source, rule penetration and rule effectiveness should also be taken into account. *Procedures For Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d, provides more detail on this.

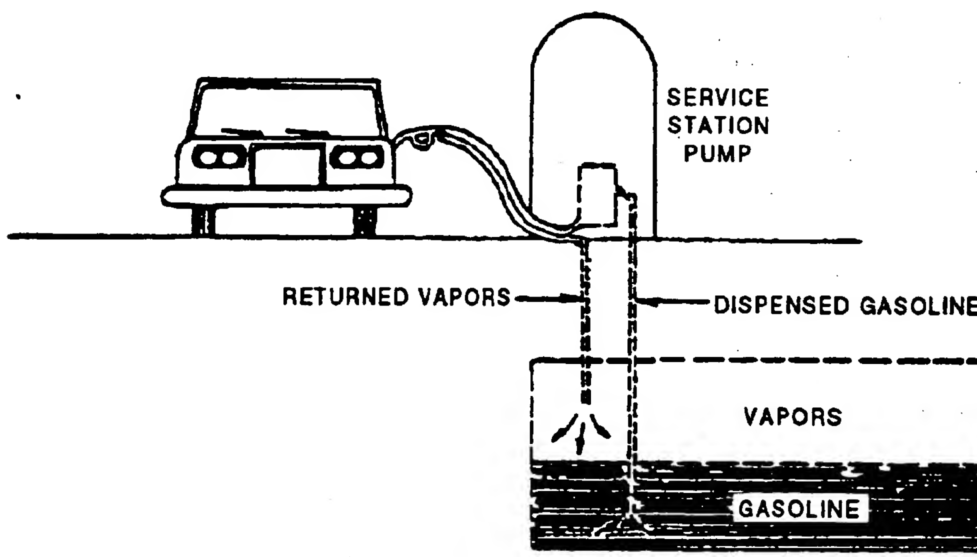

Figure 5.2-7. Automobile refueling vapor recovery system.

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5.2 RELATED EIIP DOCUMENTS

VOLUME III: CHAPTER 11

GASOLINE MARKETING (STAGE I AND STAGE II)

Revised Final
January 2001

Prepared by:
Eastern Research Group, Inc.

Prepared for:
Area Sources Committee
Emission Inventory Improvement Program

DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

ACKNOWLEDGEMENT

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CONTENTS

CONTENTS (CONTINUED)

FIGURES AND TABLES

FIGURES AND TABLES (CONTINUED)

Table **Page**

1

INTRODUCTION

This chapter is one of a series of documents developed to provide cost-effective, reliable and consistent approaches to estimating emissions for area source inventories. Multiple methods are provided in the chapters to accommodate needs of state agencies with different levels of available resources and skills; and different levels of needs for accuracy and reliability of their estimates. More information about the EIIP program can be found in Volume 1 of the EIIP series, *Introduction and Use of EIIP Guidance for Emissions Inventory Development.*

Throughout this chapter and other EIIP area source methods chapters, we stress that area source categories should be prioritized by the inventory planners so that resources can be spent on the source categories that are the largest emitters, most likely to be subject to regulations or are already subject to regulations, or require special effort because of some policy reason. Prioritization is particularly important for area source inventories, because in some cases, a difficult to characterize source category may contribute very little to overall emissions and attempting a high quality estimate for that source category may not be cost effective.

EIIP chapters are written for the state and local air pollution agencies, with their input and review. EIIP is a response to EPA's understanding that state and local agency personnel have more knowledge about their inventory area's activities, processes, emissions, and availability of information; and require flexible inventory methods to best use their sometimes limited resources. These EIIP area source chapters are written as a set of options presented to inventory professionals capable of using their own experience and judgement to apply the method that best fits their overall needs and constraints.

This chapter describes the procedures and recommended approaches for estimating emissions from gasoline tank trucks in transit and at retail gasoline marketing outlets. Section 2 of this chapter contains a general description of the gasoline distribution industry category and an overview of available control technologies. Section 3 provides an overview of available emission estimation methods. Section 4 presents the preferred method for estimating emissions, and Section 5 presents the alternative emission estimation techniques. Quality assurance issues and emission estimate quality indicators for the methods presented in this chapter are discussed in Section 6. Data coding procedures are discussed in Section 7. Section 8 contains references used for this chapter.

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2

SOURCE CATEGORY DESCRIPTION

2.1 CATEGORY DESCRIPTION

Motor gasoline is produced by domestic petroleum refineries or in some cases imported to the United States, and then transported through a distribution network to customers. The distribution network is a complex system that includes many wholesale and retail outlets. The network includes a variety of storage and transfer facilities. Gasoline may be transported by tanker ships and barges, through pipelines, or by rail tank cars or tank trucks. This chapter covers most of those sections of the distribution network where evaporative emissions are usually considered to be area sources. Stage I and Stage II emissions (occurring during the transfer of gasoline from tank trucks to storage tanks at service stations, and subsequent transfer to the vehicle gasoline tank, respectively) are covered, as well as emissions from delivery trucks in transit, gasoline station storage tanks, and spillage. Additional information about this category can be found in *AP-42* (Section 4.4) (EPA, 1995), and the *AIRS Area and Mobile Source Category Codes* (EPA, 2000).

Figure 11.2-1 shows a typical path by which gasoline may be transported from producer to consumer. This path includes operations that are not addressed in this chapter. Marine vessel loading and unloading operations are covered in Chapter 12. Bulk terminals and gasoline bulk plants, which are intermediate distribution points between refineries and outlets, are usually inventoried as point sources. Loading and unloading of railroad tank cars and pipeline transmission losses could be significant area source categories in some areas, but have not been included in this chapter.

2.2 PROCESS DESCRIPTION AND EMISSION SOURCES

The area sources of evaporative VOC emissions from the distribution of gasoline that are covered in this chapter include the following:

- Trucks in transit: evaporation of gasoline vapor (1) from loaded tank trucks during transportation of gasoline from the bulk plant/terminal to the service station or other dispensing outlet, and (2) from empty tank trucks returning from service stations to bulk plant/terminals.

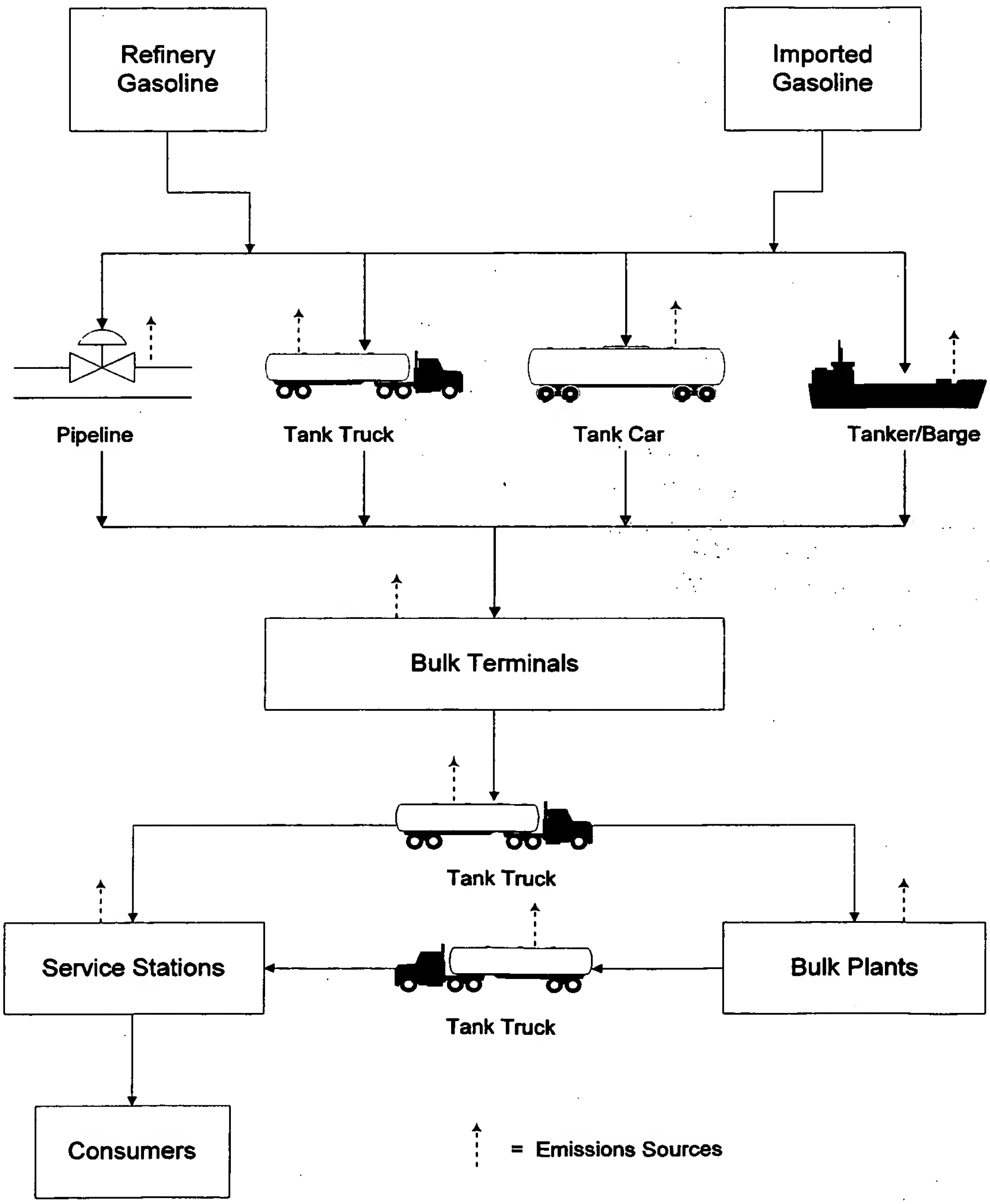

Figure 11.2-1
Gasoline Marketing Operations and Emission Sources

- Stage I: displacement of gasoline vapors from the storage tanks during the transfer of gasoline from tank trucks to storage tanks at the service station

- Stage II: displacement of gasoline vapors from vehicle gasoline tanks during vehicle refueling. This category also may include spillage of gasoline (and subsequent evaporation) during either delivery activity above. This loss includes prefill and postfill nozzle drip and spitback and overflow from the filler pipe of the vehicle's fuel tank during filling.

- Storage tank working losses: evaporation of gasoline vapors from the storage tank and from the lines going to the pumps during transfer of gasoline.

Service stations (Standard Industrial Classification code 5541) traditionally have been the primary retail distributors for gasoline. Gasoline can be purchased from other types of businesses, such as auto repair garages, parking garages, and convenience stores. Gasoline may also be distributed to vehicles through various nonretail outlets, such as government motor pools and other vehicle fleet servicing operations. Gasoline is stored in underground and aboveground storage tanks at service stations and other dispensing facilities. Evaporative emissions occur during tank filling and vehicle refueling.

2.3 FACTORS INFLUENCING EMISSIONS

VOC emissions from gasoline marketing activities are influenced by several factors. Fuel volatility (measured as Reid vapor pressure, or RVP) affects the evaporation rate of gasoline. The technology for loading tank trucks and tanks (splash loading, submerged loading, vapor balance, etc.) affects the release of displacement emissions. Tank characteristics (color and design) affect working losses from aboveground storage tanks.

2.4 CONTROL TECHNIQUES

Emissions from underground tank filling operations at service stations (Stage I emissions) can be reduced by the use of a vapor balance system, which consists of a hose that returns gasoline vapors displaced from the underground tanks during filling back to the tank truck, as well as measures to ensure tightness of the truck. The control efficiency of the balance system can range from 93 to 100 percent (EPA, 1995). Emissions from vehicle refueling (Stage II emissions) also can be reduced by a vapor balance system. During refueling, the vapors displaced from the vehicle fuel tanks are returned to the underground tanks through the use of a special nozzle (EPA, 1995). Stage I controls have been implemented in some areas, both attainment and nonattainment. Stage II controls are currently not widely implemented, but are required in some ozone nonattainment areas as defined by the 1990 Clean Air Act (CAA) (EPA, 1991).

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3

OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODOLOGIES

The following activities of the gasoline distribution industry are generally area sources of air pollution: (1) gasoline trucks in transit; (2) fuel delivery to outlets (Stage I); (3) vehicle refueling (Stage II); and (4) storage tank breathing. The emissions estimation methodologies for the subcategories of gasoline distribution identified in Section 2 have a common, simple form:

$$\text{Emissions} = \text{Emission Factor} \times \text{Activity Level} \qquad (11.3\text{-}1)$$

The methodologies for adjusting the emission factors and activity levels vary somewhat among the subcategories. Accordingly, methodologies for developing emission factors and activity levels are presented separately for each subcategory.

3.2 AVAILABLE METHODOLOGIES

Selection of the appropriate estimation method depends on the relative significance of emissions from this source in the inventory area and the data quality objectives (DQOs) of the inventory plan. Refer to EIIP Volume VI, *Quality Assurance Procedures,* Sections 2.1 and 2.4 for discussions of inventory categories and DQOs.

Methods for estimating emissions from the gasoline marketing system generally involve employing an emission factor (provided by EPA or generated with EPA's MOBILE model) relating emissions to the volume of gasoline distributed. Gasoline distribution within the study area may be determined by area-specific tax records or survey data. Unfortunately, gasoline sales tax data are not always available at the county or city level, and performing a valid survey may not be feasible due to resource limitations. Alternately, state-level gasoline sales may be allocated to the study area based on economic data (dollars of total sales, available in U.S. Bureau of the Census publications).

Emission factors for gasoline trucks in transit, fuel delivery to outlets, and storage tank breathing are all provided by EPA. No methodologies have been identified to replace the use of these emission factors. Emission factors for vehicle refueling should be developed through the use of

EPA's MOBILE model. This software uses local data (e.g., temperature, fuel volatility) to generate a custom VOC emission factor.

In selecting preferred methodologies identified for gasoline marketing subcategories, preference has been given to methodologies that maximize use of survey data or other data collected or reported at the county or city level.

3.1.1 EMISSION FACTORS

Gasoline Trucks in Transit

EPA has published emission factors for gasoline tank trucks in transit. The emission factors are included in Table 11.3-1.

TABLE 11.3-1

VOC EMISSION FACTORS FOR GASOLINE MARKETING ACTIVITIES[a]

Emission Source	mg/Liter Throughput	lb/1000 gal Throughput
Gasoline Tank Trucks in Transit		
Vapor-filled Tank Trucks[b]	6.5	0.055
Gas-filled Tank Trucks[c]	0.5	0.005
Filling Underground Tank (Stage I)		
Submerged Filling	880	7.3
Splash Filling	1,380	11.5
Balanced Submerged Filling	40	0.3
Underground Tank Breathing and Emptying[d]	120	1.0

[a] Source: *AP-42* Tables 5.2-5, 5.2-7.
[b] Midpoint of typical range provided in AP-42. Under extreme conditions, the upper end of the range is 0.37 lb/1000 gal (44.0 mg/L).
[c] Midpoint of typical range provided in AP-42. Under extreme conditions, the upper end of the range is 0.08 lb/1000 gal (9.0 mg/L).
[d] Includes any vapor less between tank and gas pump.

Emission factors can be supplemented by using the HAP speciation profiles provided in the NTI area source category, Gasoline Distribution Stage II. The NTI documentation provides profiles that can be applied to the VOC estimates for baseline, reformulated, and winter-oxygenated gasolines. The reformulated and winter-oxygenated gasolines are then subdivided depending on the additive contents, which include methyl tertiary butyl ether (MTBE) or ethanol. Table 11.3-2 displays the HAP speciation profiles that should be applied to the VOC emissions.

TABLE 11.3-2

HAP PERCENT OF VOC EMISSIONS

HAP	Gasoline Type				
	Baseline	Reformulated		Winter-Oxygenated	
		w/ MTBE	w/ Ethanol	w/ MTBE	w/ Ethanol
2,2,4-Trimethylpentane	0.8	0.7	0.7	0.7	0.7
Benzene	0.9	0.4	0.4	0.7	0.7
Ethylbenzene	0.1	0.1	0.1	0.1	0.1
Hexane	1.6	1.4	1.4	1.4	1.4
MTBE	0	8.7	0	11.9	0
POM as 16-PAH	0.05	0.05	0.05	0.05	0.05
Toluene	1.3	1.1	1.1	1.1	1.1
Xylene	0.5	0.4	0.4	0.4	0.4

Source: EPA, 1999

Fuel Delivery to Outlets

EPA has published emission factors for filling underground storage tanks (Stage I). The emission factors are included in Table 11.3-1.

Vehicle Refueling

EPA recommends that the MOBILE model be used to generate refueling (Stage II) emission factors for highway vehicle emission inventories (EPA, 1992b). The model, designed to support the evaluation of air pollution from gasoline- and diesel-fueled vehicles, generates emission

factors for tailpipe emissions and refueling activities. A detailed discussion of using this model is available from EPA (EPA, 1994).

The MOBILE model allows the user to select whether refueling emission factors are presented in grams per gallon (g/gal) of dispensed fuel or in grams per mile (g/mi). The preferred approach is to use the g/gal refueling emission factor that reflects any applicable Stage II controls, then multiply the emission factor by total gasoline sales (TGD). Using the g/gal emission factor will capture refueling emissions from gasoline purchased in the study area but consumed outside the study area. Conversely, the g/mi emission factor will assign to the study area emissions for vehicles refueled outside the study area but driven within the study area. It should be noted that MOBILE makes use of improved predictive equations to calculate refueling emission factors, including sensitivity to temperature and Reid vapor pressure (RVP), and these have not yet been incorporated into published *AP-42* factors for refueling. Additionally, the user may provide information on local Stage II emission controls to develop an emission factor for controlled emissions.

Refueling emissions have two mechanisms of introducing emissions to the environment: (1) vapor displacement from the vehicle fuel tank during refilling; and (2) gasoline spillage during refueling. The MOBILE user may request either a single emission factor that combines the two mechanisms or separate emission factors for displacement and spillage. Because both mechanisms should be taken into account when estimating refueling emissions, the preferred approach is to request the combined emission factor.

Storage Tank Breathing

EPA has published emission factors for storage tank breathing. The emission factors are included in Table 11.3-1.

3.1.2 ACTIVITY LEVELS

All of the preferred methodologies discussed in this document use total gasoline distribution as activity levels. The most useful source of existing data for estimating total gasoline distributed (TGD) in the inventory area is any existing collection of highway fuel sales data. The preferred approach to estimating TGD is to use these data. If available, these data should be collected, assessed, and processed to ensure that only highway vehicle gasoline dispensed in the area of concern is included in the total to be used as TGD. According to a recent EPA study, only 10 states actually collect and publish this type of data: Alabama, Arizona, Florida, Hawaii, Mississippi, Nevada, New Mexico, New York, Washington and, Wyoming. Most of the states with significant nonattainment problems are absent from this list. In addition, the reliability of these statistics as measures of gasoline distributed at the county level is unknown; significant errors in allocation may occur if statistics are based on locations of distributors and not all of this

fuel supply remains in the area of concern, or if substantial quantities of fuel come from distributors outside the area.

Where adequate data are not routinely collected, the only other alternatives for developing county-level data are (1) to collect sales tax data from the state taxing agency, if these data are available at sufficient disaggregation, or (2) to generate original data by collecting gasoline sales data from fuel distributors and retailers. State taxing agencies typically cannot provide the level of geographic detail necessary for inventory application; fuel taxes are usually collected from distributors rather than retailers, and these data are often considered proprietary information. Any tax-based estimates should be cross-checked with data from associations of service station owners, distributors, and other local sources. The large number of retailers and ongoing changes in retailer locations and ownership can make an original survey costly and difficult, although a small area might find this a reasonable approach. Scaling survey results to account for outlets not surveyed and/or nonresponders is also problematic; however, this could be accomplished using employment data for SIC Code 5541 or data on the total numbers of outlets in the area. One advantage of this approach is that information on the amount of gasoline distributed under different types of emission control scenarios can be directly estimated.

Another alternative for estimating gasoline consumption is to use data from various national publications. The Federal Highway Administration (FHWA) annually publishes *Highway Statistics*, which contains gasoline consumption data for each state.[1] Countywide estimates can be made by apportioning these statewide totals by the percentage of state gasoline station sales occurring within each county. Countywide service station gasoline sales data (dollars of sales, not gasoline volume) are available from the Bureau of the Census's *Census of Retail Trade*.[2] (Note: Data in the *Census of Retail Trade* are usually too old to use directly in estimating countywide sales; however, they are useful in allocating other data to the county level.) Other apportioning variables, such as registered vehicles or vehicle miles traveled (VMT), can be used if the local agency feels that their use results in more accurate distributions of state totals to the county level. Even if the agency uses local sales data in the area source inventory, this approach should be used as a cross-check of the local consumption estimates. One distinct advantage of using data in *Highway Statistics* is that sales are tabulated by month which facilitates a seasonal adjustment of the gasoline station emission totals.

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1 *Highway Statistics*. U.S. Department of Transportation. Federal Highway Administration, Washington, D.C. (Annual publication. Check USDOT/FHWA Web site for latest version, http://www.fhwa.dot.gov).

2 *Census of Retail Trade: Geographic Area Series*. Bureau of the Census, U.S. Department of Commerce, Washington, D.C. (Available on hard copy by contracting the Census Bureau at 1-800-541-8345 or see the Census Bureau Web site, http://www.census.gov. Alternatively, check http://sasquatch.kerr.orst.edu/econ-stateis.html.

Another method of estimating gasoline sales is to use VMT data available from the ongoing transportation planning process. This alternative is not generally recommended for several reasons. First, it requires local information on both the percentage of VMT attributable to diesel versus gasoline fuel and the average miles-per-gallon fuel efficiency of the gasoline-powered motor fleet. None of these data may be available locally, and using nationwide averages may introduce errors in certain applications. Moreover, highway travel will not account for all gasoline sold at various off-highway applications. For these reasons, fuel sales is the preferred method for determining fuel use.

Note: Using state or local air pollution permit files for inventorying gasoline dispensing outlets is not likely to be an effective alternative. Permit information is not usually collected because of the large number of stations and because each station's emissions are much lower than traditional point source cutoff levels. Registration systems are being attempted in some states where major retail chains are required to compile and submit service station lists. Such a detailed approach is not usually warranted when gasoline distribution data will yield adequate emissions estimates.

Gasoline Trucks in Transit

The activity level for estimating emissions from gasoline trucks in transit is fuel transported through the study area. In order of preference, the available methods for estimating fuel throughput include: (1) obtaining (if available) existing gasoline sales data for the study area; and (2) apportioning state gasoline sales data to the study area level using surrogate allocation variables such as gasoline sales, vehicle registration, or economic activity data.

Gasoline distributed in an inventory area may be transported once (from bulk terminals outside the study area to retail outlets) or twice (distribution to gasoline bulk plants, then subsequent distribution to retail outlets). Recent industry trends favor more direct delivery to outlets, bypassing bulk plants.

The following equation can be used to develop an adjusted gasoline transportation activity factor for trucks in transit to account for gasoline transported twice within the inventory region:

$$GTA = \frac{TGD + TGT}{TGD} \qquad (11.3\text{-}2)$$

where:

GTA	=	Gasoline transportation adjustment factor
TGD	=	Total gasoline dispensed in the inventory region (1,000 gallons)
TGT	=	Amount of gasoline transported twice within the inventory region (1,000 gallons)

A default value of 1.25 for GTA can be used if the information needed to calculate GTA is not available. This default value is based on an estimated overall historical national ratio of bulk plant throughput to total gasoline consumption and should be used only as a last resort since it will not reflect temporal or regional variations from this national historical average.

Depending on the location of nearby gasoline terminals and routes used to deliver product to remote bulk plants or outlets, there may be some inventory areas with heavy tank truck traffic on local interstates consisting of gasoline being transported through the area but not loaded or unloaded locally. There are currently no adjustment factors for this specific type of activity. However, it may be possible to obtain data on this type of traffic from weigh stations on interstate highways and add this throughput to the estimate of TGD in the area to obtain an upper-limit estimate for total emissions for trucks in transit including transport through the area (assuming that the factors for full and empty trucks are appropriate in this case). Inventory preparers may want to make a gross estimate of the contribution to overall emissions that these trucks may make before investing significant resources in this effort. (Typical round-trip emissions for each truck are probably less than 1 pound of VOCs.)

Total gasoline tank truck emissions (TTE) in the inventory region can be estimated with the following equation:

$$TTE = \frac{(TGD \times LEF \times GTA) + (TGD \times UEF \times GTA)}{2000} \qquad (11.3\text{-}3)$$

where:

TTE = Total gasoline emissions from tank trucks in transit (tons)

LEF = Loaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)

UEF = Unloaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)

Fuel Delivery to Outlets

In order to use the emission factors for fuel delivery to outlets included in Table 11.3-1, it may be necessary to make estimates of the amounts of fuel delivered by each delivery technology (submerged filling, splash filling, balanced submerged filling). The first step is to determine what rules are in place for Stage I tank filling. If a rule requires a certain type of control or filling method, then the inventory preparer need only determine a rule penetration factor. Otherwise, estimates of or surrogates for the volumes of fuel delivered via each filling method are required. Potential methodologies for making these estimates include:

Method 1 - Obtain estimates of gasoline delivery volumes: Obtain data on throughput of area gasoline outlets from state/local regulators or industry and trade groups (the national Petroleum Marketing Association, located in Arlington, Virginia, or state/local associations of gasoline dealers and repair shops). This is the preferred method.

Method 2 - Use estimated fractions of service stations using each filling method: Obtain the number of gasoline outlets that use each of the three types of tank filling methods from state and local regulators or industry and trade groups. Distribute gasoline delivery volumes according to these results.

Method 3 - Survey of outlets by filling method: Perform a survey of all or a representative sample of gasoline dispensing outlets in the inventory region to determine the type of tank filling method. Distribute gasoline delivery volumes according to these results. A survey design must ensure that the sample selected is representative. It is likely that smaller stations may use different controls or filling methods than larger ones. A sample should be stratified to ensure that all types of outlets are included. The survey needs to collect gasoline throughput data and other data that may be used to scale survey results to study area totals. Potential surrogates may be number of employees, number of pumps, or storage tank capacities.

The activity levels for each of the three fuel delivery technologies is then calculated as follows:

$$A_i = F_i \times TGD \qquad (11.3\text{-}4)$$

where:

A_i = Adjusted activity rate for fill type I (1,000 gallons)
F_i = Fraction of area total for fill type I (based on either throughput or number of stations)
TGD = Total gasoline dispensed in the inventory region (1,000 gallons)
I = 1-3 representing the three filling methods

Vehicle Refueling

The activity factor for vehicle refueling can be either the total amount of gasoline distributed in the area or vehicle miles of travel (VMT). The preferred approach is to use estimates of local gasoline sales if these data are available.

- Obtain information on the amount of gasoline dispensed in the inventory region (TGD) using the methods described previously in this section. Use the best locally available estimate of TGD as the activity factor for vehicle refueling.

- If no local sources of information are available for estimating TGD, the agency may wish to use VMT as an alternative. Estimates of VMT should be obtained from the local transportation or planning agency who is responsible for preparing the highway vehicle emissions inventory. The disadvantage of using VMT is that it is a measure of vehicle activity in the area not a measure of the fuel dispensed in the inventory area. VMT produced by vehicles simply passing through the area, that did not refuel in the inventory region would tend to overstate the vehicle refueling activity level.

Storage Tank Breathing

The activity level for estimating emissions from storage tank breathing is total gallons delivered (TGD) in the inventory area. The methodology for estimating TGD for vehicle refueling is also recommended for this subcategory.

3.1.3 SPECIAL EMISSION CALCULATION ISSUES

Estimation of month-specific emissions from gasoline distribution can be based on activity apportionment factors developed from monthly state fuel use statistics available in *Highway Statistics*. Projections for fuel use can also be based on historic fuel use and vehicle miles traveled data from *Highway Statistics*, historic records from the sources from which current year area fuel usage was obtained, and/or area-specific VMT from Highway Performance Monitoring System (HPMS) (from Federal Highway Administration, Washington, DC) or local transportation agencies.

3.1.4 METHODOLOGY SUMMARIES

The methodologies proposed in this document are summarized in Table 11.3-3 below. Preferred and alternate methodologies are presented for each of the subcategories.

3.3 DATA NEEDS

3.3.1 DATA ELEMENTS

The data elements needed to calculate emission estimates for the gasoline distribution system depend on the methodology used for data collection. Each methodology requires some measure of activity (or surrogate for activity) and an emission factor. The data elements needed for each emission estimation technique are presented in Table 11.3-4.

TABLE 11.3-3

PREFERRED AND ALTERNATE METHODS FOR ESTIMATING EMISSIONS FROM GASOLINE DISTRIBUTION SUBCATEGORIES

Sub-category	Method	Description
Gasoline Trucks in Transit	Preferred Method - Use detail or survey data	*Emission Factors* - from Table 3-1. *Activity Level* - Obtain fuel sales from tax records or survey data. Develop adjustment factor based on survey or highway-weigh station data.
	Alternate Method 1 - Use combination of default and detailed data	*Emission Factor* - from Table 3-1. *Activity Level* - Same as preferred method, substituting default GTA.
	Alternate Method 2 - Use default GTA and allocated fuel sales data	*Emission Factor* - from Table 3-1. *Activity Level* - Same as preferred method, substituting default GTA, allocate state fuel sales to study area based on gasoline station sales.
Fuel Delivery to Outlets	Preferred Method - Use detail or survey data	*Emission Factor* - from Table 3-1. *Activity Level* - Obtain fuel sales from tax records or survey data. Use survey data to determine filling technologies.
	Alternate Method 1 - Use allocated fuel sales data, survey filling data	*Emission Factor* - from Table 3-1. *Activity Level* - Same as preferred method, using allocated fuel sales estimates instead of actual data. Use survey data to determine filling technologies' usage.
	Alternate Method 2 - Use allocated fuel sales data, local knowledge of filling technology	*Emission Factor* - from Table 3-1. *Activity Level* - Same as preferred method, using allocated fuel sales estimates instead of actual data. Use trade association or local knowledge to determine filling technologies' usage.
Vehicle Refuel-ing	Preferred Method - Use MOBILE emission factor and detail or survey data	*Emission Factor* - use MOBILE emission factor. *Activity Level* - Obtain fuel sales from tax records or survey data.
	Alternate Method 1 - Use MOBILE emission factor, allocated fuel sales	*Emission Factor* - use MOBILE emission factor. *Activity Level* - use allocated fuel sales estimates instead of actual data.
	Alternate Method 2 - Use MOBILE emission factor, vehicle miles traveled (VMT) data	*Emission Factor* - use MOBILE emission factor to get emission factor in dimensions grams per mile traveled. *Activity Level* - Get VMT data from highway planners.
Storage Tank Breath-ing	Preferred Method - Use EPA emission factor and detail or survey data	*Emission Factor* - see Table 3-1. *Activity Level* - Obtain fuel sales from tax records or survey data.
	Alternate Method 1 - Use EPA emission factor, allocated fuel sales	*Emission Factor* - see Table 3-1. *Activity Level* - Use allocated fuel sales estimates instead of actual data.

TABLE 11.3-4

DATA ELEMENTS NEEDED FOR EACH METHOD

Subcategory	Data Element	Preferred Method	Alternate Method 1	Alternate Method 2
Gasoline Trucks in Transit	County-level fuel sales tax/survey data	X	X	
	Highway/weigh-station data	X		
	State fuel sales			X
	Gasoline station sales			X
Fuel Delivery to Outlets	County-level fuel sales tax/survey data	X		
	Filling technology survey data	X	X	
	Filling technology summary from local/state regulators or trade groups			X
	State fuel sales		X	X
	Gasoline station sales		X	X
Vehicle Refueling	MOBILE model inputs (see Reference 8)	X	X	X
	County-level fuel sales tax/survey data	X		
	State fuel sales		X	
	Gasoline station sales		X	
	VMT data			X
Tank Breathing	County-level fuel sales Tax/survey data	X		
	State fuel sales		X	
	Gasoline station sales		X	

3.3.2 ADJUSTMENTS TO EMISSIONS ESTIMATES

Adjustments applied to annual emissions estimates include point source corrections, applications of controls, spatial allocation, and temporal resolution. The type of adjustment is dependent on the type of inventory required. The data needs for point source emission estimate adjustments are dependent in part on the methodology used. Data needs for the adjustments listed below are as follows:

- Point source corrections — point source emissions or point source employment for inventory area for the specific SIC
- Application of controls — control efficiency, rule effectiveness, rule penetration
- Spatial allocation — employment, population, facility location, zoning or business districts location
- Temporal resolution — seasonal throughput, operating days per week, operating hours per day

3.3.3 POINT SOURCE CORRECTIONS

If the preferred method is used to estimate area source emissions from this category, the point source correction is performed as part of the method itself. If Alternate Method 1 is used, the point source corrections can be performed by one of the following: (1) subtract point source emissions from calculated total emissions, or (2) subtract point source employment in the specific SIC from total employment in that SIC and calculate area source emissions using the remaining employment in the SIC. If Alternate Method 2 is used, the point source corrections are performed by subtracting point source emissions from calculated total emissions.

3.3.4 APPLICATION OF CONTROLS

Section 3.8 of *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I,* (EPA, 1991) provides guidance for determining and applying rule effectiveness (RE) for a source category. In addition, the EPA document *Procedures for Estimating and Applying Rule Effectiveness in Post-1987 Base Year Emission Inventories for Ozone and Carbon Monoxide State Implementation Plans* (EPA, 1989) provides more detailed information on RE.

Controlled area source emissions may be calculated with either of the following equations:

$$CAE_A = (EF_A)(Q)[1 - (CE)(RP)(RE)] \tag{11.3-5}$$

or

$$CAE_A = (UAE_A)[1 - (CE)(RP)(RE)]$$

where: CAE_A = controlled area source emissions of pollutant A
EF_A = emission factor for pollutant A
Q = activity factor for category
CE = control efficiency/100
RP = rule penetration/100
RE = rule effectiveness/100
UAE_A = uncontrolled area source emissions of pollutant A

3.3.5 Spatial Allocation

If the emissions estimates are developed using a per employee factor, the spatial allocation of emissions can be performed according to facility location (if known) as with the point source inventory, or with local employment data. The agency should be aware that since location of gasoline marketing does not necessarily mirror location of population within a county, using population to spatially allocate emissions might be misleading. The inventorying agency will need to evaluate options for allocating county emissions, such as zoning information, actual location data identified from surveys, industry publications, etc.

3.3.6 Temporal Resolution

Seasonal Apportioning

Because emissions from these subcategories are generally directly proportional to fuel sales and fuel sales have well-documented seasonal trends, annual gasoline distribution emissions should be apportioned monthly based on fuel sales data. Fuel sales tax revenues are usually available from state departments of revenue and should be used to allocate emissions.

Daily/Hourly Resolution

As with all issues, the inventory agency should use local data if available. If no data are available, inventory agencies may use the Table 11.3-5 as default values:

TABLE 11.3-5

DAILY AND HOURLY ALLOCATION OF GASOLINE DISTRIBUTION SYSTEM EMISSIONS

Subcategory	Daily Allocation (days per week)	Hourly Allocation (hours per day)
Trucks in Transit	6	24
Fuel Delivery to Outlets	6	24
Vehicle Refueling	7	24
Storage Tank Breathing	7	24

3.4 PROJECTING EMISSIONS

The type of surrogate used to project emissions is dependent on the methodology used to develop the initial emissions estimate. In "growing" the emissions estimate, the inventorying agency should use the same activity parameter as was used to develop the initial estimate. For example, if a per gallon factor was used to develop the initial estimate, growth in gasoline sales should be used to develop the projected emissions estimate.

The EIIP Projections Committee has developed a series of guidance documents containing information on options for forecasting future emissions. You can refer to these documents at http://www.epa.gov/ttn/chief/eiip/project.htm.

4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

The following procedures should be used for estimating emissions from the gasoline distribution subcategories. See Section 3 for additional guidance for the application of these methods.

4.1 GASOLINE TRUCKS IN TRANSIT

(1) Consult state gasoline sales tax records or data collected through a survey of fuel distributors and retailers to determine the gasoline consumption in the study area.

(2) Obtain highway weigh-station data to estimate the amount of fuel transported through the area. Calculate GTA, the factor accounting for twice-transported fuel:

$$GTA = \frac{TGD + TGT}{TGD} \qquad (11.4\text{-}1)$$

where:

GTA = Gasoline transportation adjustment factor
TGD = Total gasoline dispensed in the inventory region (1,000 gallons)
TGT = Amount of gasoline transported twice within the inventory region (1,000 gallons)

(3) Calculate emissions:

$$TTE = \frac{(TGD \times LEF \times GTA) + (TGD \times UEF \times GTA)}{2000} \qquad (11.4\text{-}2)$$

where:

TTE = Total gasoline emissions from tank trucks in transit (tons)
LEF = Loaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)
UEF = Unloaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)

4.2 FUEL DELIVERY TO OUTLETS

(1) Consult gasoline sales tax records or survey data to determine the gasoline consumption in the study area.

(2) Use survey data to determine penetration of each filling technology.

(3) Multiply total fuel sales in the study area by the fraction of stations using each filling technology to estimate the fuel dispensed by each technology.

(4) Use technology-specific emission factors to estimate emissions from submerged filling, splash filling, and vapor-balanced submerged filling activities.

(5) Sum emissions from each technology to estimate total emissions.

4.3 VEHICLE REFUELING

(1) Consult gasoline sales tax records or survey data to determine the total amount of gasoline dispensed in the study area.

(2) From the local control agency or survey data, determine the level of local Stage II refueling controls.

(3) Run the MOBILE model to determine the emission rate on a mass per volume throughput (grams per gallon, converted to pounds per gallon) basis. (In MOBILE5b, this is accomplished by setting HCFLAG = 3). Based on the results of step 2, determine whether Stage II refueling controls need to be considered. If local stage II controls are in place, enter the appropriate data in the MOBILE one-time data section per MOBILE model requirements (EPA, 1994). (In MOBILE5b, set RLFLAG = 1 if there are no local Stage II controls, or set RLFLAG = 2 to calculate an emission factor that includes local Stage II controls. Note that MOBILE5b will factor in the effects of the national on-board vapor recovery system requirements for either value of RLFLAG.) MOBILE6 is due for release in 2000. The reader should check the OTAQ Website for updated information on MOBILE6 (www.epa.gov/oms/m6.htm).

(4) Multiply the emission factor (lb/gallon of fuel) times the estimated gasoline volume (gallons of gasoline) to estimate emissions from vehicle refueling.

4.4 STORAGE TANK BREATHING

(1) Consult gasoline sales tax records or survey data to determine the gasoline consumption in the study area.

(2) Multiply gasoline sales (gallons) times the emission factor to estimate emissions from storage tank breathing.

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5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

Frequently, local county-level sales tax data for gasoline sales or other local data needed to adjust these values are not available. Also, the collection of local gasoline sales data through surveys of distributors and retailers may be impractical or too expensive. Under these circumstances, use of one of the following alternative methods is appropriate.

5.1 ALTERNATIVE METHOD 1

5.1.1 GASOLINE TRUCKS IN TRANSIT

This method is the same as the preferred method, except that a default factor is used to estimate the adjustment factor for gasoline transported twice in the inventory area.

(1) Consult gasoline sales tax records or survey data to determine the gasoline consumption in the study area.

(2) Use 1.25, a national default rate, as GTA (gasoline transportation adjustment factor).

(3) Calculate emissions:

$$TTE = \frac{(TGD \times LEF \times GTA) + (TGD \times UEF \times GTA)}{2000} \qquad (11.5\text{-}1)$$

where:

TTE	=	Total gasoline emissions from tank trucks in transit (tons)
LEF	=	Loaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)
UEF	=	Unloaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)

5.1.2 FUEL DELIVERY TO OUTLETS

This method apportions state-level data to counties instead of using local sales tax or survey data.

(1) Assume that gasoline consumption is proportional to gasoline station sales, reported in the Bureau of the Census's *Census of Retail Trade.* Allocate state gasoline consumption data from *Highway Statistics* to the study area according to the dollar sales figures reported in the *Census of Retail Trade.*

(2) Use survey data to determine penetration of each filling technology.

(3) Multiply total fuel sales in the study area by the fraction of stations using each filling technology to estimate the fuel dispensed by each technology.

(4) Use technology-specific emission factors to estimate emissions from submerged filling, splash filling, and vapor-balanced submerged filling activities.

(5) Sum emissions from each technology to estimate total emissions.

5.1.3 VEHICLE REFUELING

(1) Allocate state gasoline consumption from *Highway Statistics* to the study area. Assume that gasoline consumption is proportional to gasoline station sales, reported in the Bureau of the Census's *Census of Retail Trade.*

(2) From the local control agency or survey data, determine the level of local Stage II refueling controls.

(3) Run the MOBILE model to determine the emission rate on a mass per volume throughput (grams per gallon, converted to pounds per gallon) basis. (In MOBILE5b, this is accomplished by setting HCFLAG = 3). Based on the results of Step 2, determine whether Stage II refueling controls need to be considered. If local Stage II controls are in place, enter the appropriate data in the MOBILE one-time data section per MOBILE model requirements (EPA, 1994). (In MOBILE5b, set RLFLAG = 1 if there are no local Stage II controls, or set RLFLAG = 2 to calculate an emission factor that includes local Stage II controls. Note that MOBILE5b will factor in the effects of the national on-board vapor recovery system requirements for either value of RLFLAG.) MOBILE6 is due for release in 2000. The reader should check the OTAQ Website for updated information on MOBILE6 (www.epa.gov/oms/m6.htm).

(4) Multiply the emission factor (lb/gallon of fuel) times the estimated gasoline volume (gallons of gasoline) to estimate emissions from vehicle refueling.

5.1.4 STORAGE TANK BREATHING

(1) Allocate state gasoline consumption from *Highway Statistics* to the study area. Assume that gasoline consumption is proportional to gasoline station sales, reported in the Bureau of the Census's *Census of Retail Trade.*

(2) Multiply gasoline sales (gallons) times the Table 11.3-1 emission factor to estimate emissions from storage tank breathing.

5.2 ALTERNATIVE METHOD 2

5.2.1 GASOLINE TRUCKS IN TRANSIT

(1) Allocate state gasoline consumption from *Highway Statistics* to the study area. Assume that gasoline consumption is proportional to gasoline station sales, reported in the Bureau of the Census's *Census of Retail Trade.*

(2) Use 1.25, a national default rate, as GTA.

(3) Calculate emissions:

$$TTE = \frac{(TGD \times LEF \times GTA) + (TGD \times UEF \times GTA)}{2000} \qquad (11.5\text{-}2)$$

where:

TTE	=	Total gasoline emissions from tank trucks in transit (tons)
LEF	=	Loaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)
UEF	=	Unloaded tank truck in-transit emission factor from Table 11.3-1 (pounds per 1,000 gallons)

5.2.2 FUEL DELIVERY TO OUTLETS

(1) Allocate state gasoline consumption from *Highway Statistics* to the study area. Assume that gasoline consumption is proportional to gasoline station sales, reported in the Bureau of the Census's *Census of Retail Trade.*

(2) Use advice of local trade groups, industry representatives, or regulators to determine penetration of each filling technology.

(3) Multiply total fuel sales in the study area by the fraction of stations using each filling technology to estimate the fuel dispensed by each technology.

(4) Use technology-specific emission factors to estimate emissions from submerged filling, splash filling, and vapor-balanced submerged filling activities.

(5) Sum emissions from each technology to estimate total emissions.

5.2.3 VEHICLE REFUELING

(1) Consult state or local transportation planners to obtain VMT data for the study area.

(2) From the local control agency or survey data, determine the level of local Stage II refueling controls.

(3) Run the MOBILE model to determine the emission rate on a mass per vehicle-mile (grams per vehicle mile traveled, converted to pounds per mile) basis. (In MOBILE5b, this is accomplished by setting HCFLAG = 2). Based on the results of Step 2, determine whether Stage II refueling controls need to be considered. If local Stage II controls are in place, enter the appropriate data in the MOBILE one-time data section per MOBILE model requirements (EPA, 1994). (In MOBILE5b, set RLFLAG = 1 if there are no local Stage II controls, or set RLFLAG = 2 to calculate an emission factor that includes local Stage II controls. Note that MOBILE5b will factor in the effects of the national on-board vapor recovery system requirements for either value of RLFLAG.)MOBILE6 is due for release in 2000. The reader should check the OTAQ Website for updated information on MOBILE6 (www.epa.gov/oms/m6.htm).

(4) Multiply the emission factor times the VMT estimates to estimate emissions from vehicle refueling.

5.2.4 STORAGE TANK BREATHING

Only one alternate methodology is provided for this category.

6

QUALITY ASSURANCE/ QUALITY CONTROL

Data collection and handling for the gasoline marketing source category should be planned and documented in the Quality Assurance Plan. When using survey methods, the survey planning and data handling should also be documented. Refer to the discussion of survey planning and survey QA/QC in Chapter 1, *Introduction to Area Source Emission Inventory Development*, of this volume, and the QA volume (VI) of the Emission Inventory Improvement Program (EIIP) series. Potential pitfalls to avoid when developing emission estimates by using a survey for this category are data gaps due to survey nonreturns or unidentified operations, unanswered or misunderstood survey questions, inappropriate assumptions used to compensate for missing information or scaling up the survey sample, and errors in compiling the returned survey information. Potential errors that are common to many area source methods are calculation errors, which can include unit conversion errors and data transfer errors.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

In this chapter, four subcategories of emission sources are discussed. Emission estimation for all of the subcategories requires the amount of gasoline sold in the inventory area as the activity level. The preferred methods call for detailed gasoline sales data that may not be available at the county or study area level. While using the most accurate fuel distribution data available is important, if the data are not immediately available, conducting a survey to determine actual gasoline distribution data is difficult, expensive, and time consuming. Allocating fuel distribution to the county level using gasoline station sales is estimated to require from 20 to 30 hours of technical effort, while performing a survey would probably take several months and possibly 1,000 to 2,000 hours of technical effort.

6.1.1 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The Data Attribute Rating System (DARS) has been developed as a tool to rate emission inventories. A description of the system and the EIIP recommendations for its use can be found in Appendix F of EIIP Volume VI, Quality Assurance Procedures. The following discussion uses the DARS rating system as a way to compare the estimation approaches presented in this chapter and analyze their strengths and weaknesses.

The DARS scores for methods for tank trucks in transit are summarized in Tables 11.6-1 through 11.6-3; for fuel delivery to outlets, in Tables 11.6-4 through 11.6-6; for vehicle refueling, in Tables 11.6-7 through 11.6-9; and for storage tank breathing, in Tables 11.6-10 and 11.6-11. A range of scores is provided for activity attributes when the recommended method for activity data collection uses either local tax data or survey results scaled to the inventory area. The higher scores are assigned to the local tax data because local tax data are the most direct measure of local data for the inventory period. Survey data require a scaling step, which introduces potential over- or underestimation. All scores assume that satisfactory QA/QC measures are performed and no significant deviations from good inventory practice have been made. If these assumptions are not met, new DARS scores should be developed according to the guidance provided in the QA volume.

TABLE 11.6-1

PREFERRED METHOD DARS SCORES: TANK TRUCKS IN TRANSIT; LOCAL GASOLINE SALES, ADJUSTMENT FACTOR FROM HIGHWAY WEIGH-STATION DATA

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.6 - 0.9	0.42 - 0.63
Source Specificity	0.6	0.4 - 0.5	0.24 - 0.30
Spatial Congruity	0.7	0.7 - 1	0.49 - 0.70
Temporal Congruity	0.5	0.7 - 0.8	0.35 - 0.40
Composite Scores	0.63	0.60 - 0.80	0.37 - 0.51

TABLE 11.6-2

ALTERNATIVE METHOD 1 DARS SCORES: TANK TRUCKS IN TRANSIT; LOCAL GASOLINE SALES, DEFAULT ADJUSTMENT FACTOR

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.6 - 0.9	0.42 - 0.63
Source Specificity	0.6	0.7 - 0.9	0.42 - 0.54
Spatial Congruity	0.7	0.5 - 0.8	0.37 - 0.53
Temporal Congruity	0.5	0.5 - 0.6	0.26 - 0.30
Composite Scores	0.63	0.59 - 0.79	0.37 - 0.50

TABLE 11.6-3

ALTERNATIVE METHOD 2 DARS SCORES: TANK TRUCKS IN TRANSIT; SCALED STATE-LEVEL GASOLINE SALES, DEFAULT ADJUSTMENT FACTOR

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.6	0.42
Source Specificity	0.6	0.7	0.42
Spatial Congruity	0.7	0.5	0.37
Temporal Congruity	0.5	0.5	0.26
Composite Scores	0.63	0.59	0.37

TABLE 11.6-4

PREFERRED METHOD DARS SCORES: FUEL DELIVERY TO OUTLETS; LOCAL GASOLINE SALES, FILLING METHOD FROM SURVEY

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.7	0.4 - 0.5	0.29 - 0.38
Source Specificity	0.7	0.4 - 0.5	0.24 - 0.32
Spatial Congruity	0.7	0.7 - 1	0.49 - 0.70
Temporal Congruity	0.5	0.7 - 0.8	0.35 - 0.40
Composite Scores	0.65	0.54 - 0.70	0.34 - 0.45

TABLE 11.6-5

ALTERNATIVE METHOD 1 DARS SCORES: FUEL DELIVERY TO OUTLETS; SCALED STATE-LEVEL GASOLINE SALES, FILLING METHOD FROM SURVEY

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.7	0.4	0.29
Source Specificity	0.7	0.4	0.24
Spatial Congruity	0.7	0.6	0.42
Temporal Congruity	0.5	0.7	0.35
Composite Scores	0.65	0.52	0.33

TABLE 11.6-6

ALTERNATIVE METHOD 2 DARS SCORES: FUEL DELIVERY TO OUTLETS; SCALED STATE-LEVEL GASOLINE SALES, FILLING METHOD FROM TRADE GROUPS

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.4	0.29
Source Specificity	0.8	0.4	0.29
Spatial Congruity	0.7	0.6	0.42
Temporal Congruity	0.5	0.7	0.35
Composite Scores	0.65	0.54	0.34

TABLE 11.6-7

PREFERRED METHOD DARS SCORES: VEHICLE REFUELING; LOCAL GASOLINE SALES, FILLING METHOD FROM REGULATORS

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.8	0.4 - 0.7	0.32 - 0.56
Source Specificity	0.8	0.6 - 0.8	0.48 - 0.64
Spatial Congruity	1	0.7 - 1	0.70 - 1.00
Temporal Congruity	0.9	0.7 - 0.8	0.63 - 0.72
Composite Scores	0.88	0.60 - 0.83	0.53 - 0.73

TABLE 11.6-8

ALTERNATIVE METHOD 1 DARS SCORES: VEHICLE REFUELING; SCALED STATE-LEVEL GASOLINE SALES, FILLING METHOD FROM SURVEY

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.4	0.28
Source Specificity	0.8	0.6	0.48
Spatial Congruity	1	0.6	0.60
Temporal Congruity	0.9	0.7	0.63
Composite Scores	0.85	0.58	0.50

TABLE 11.6-9

ALTERNATIVE METHOD 2 DARS SCORES: VEHICLE REFUELING; GASOLINE USE FROM VMT, FILLING METHOD FROM SURVEY

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.8	0.4	0.28
Source Specificity	0.8	0.4	0.32
Spatial Congruity	1	0.7	0.70
Temporal Congruity	0.9	0.7	0.63
Composite Scores	0.85	0.55	0.48

TABLE 11.6-10

PREFERRED METHOD DARS SCORES: STORAGE TANK BREATHING; LOCAL GASOLINE SALES

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.6 - 0.9	0.42 - 0.63
Source Specificity	0.7	0.7 - 0.9	0.49 - 0.63
Spatial Congruity	0.7	0.7 - 1	0.49 - 0.70
Temporal Congruity	0.5	0.7 - 0.8	0.35 - 0.40
Composite Scores	0.65	0.68 - 0.90	0.44 - 0.59

TABLE 11.6-11

ALTERNATIVE METHOD 1 DARS SCORES: STORAGE TANK BREATHING; SCALED STATE-LEVEL GASOLINE SALES

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.7	0.6	0.42
Source Specificity	0.7	0.7	0.49
Spatial Congruity	0.7	0.6	0.42
Temporal Congruity	0.5	0.7	0.35
Composite Scores	0.65	0.65	0.42

All of the emission calculation methods for tank trucks in transit, fuel delivery to outlets, and storage tank breathing use emission factors from *AP-42*. Important points to consider when scoring the emission factor component of these methods are that the factors are based on studies published in 1982 and that local temperature variations and gasoline Reid vapor pressure (RVP) are not factored into the emission calculation. The age of the emission data means that any changes in gasoline formulation and improvements in vapor control technology since 1982 will not be reflected in the emission factors. DARS scoring for all of the *AP-42* emission factors are the same except for the tank trucks in-transit subcategory. The scores for emission factor source specificity for tank trucks in transit are lower than for other subcategories because the factors provided in this chapter are averages of ranges provided in *AP-42*.

The emission factor recommended for the vehicle refueling subcategory was developed using the MOBILE model, and is a factor that expresses refueling emissions as a function of fuel RVP, temperature of dispensed fuel, and the difference in the temperature between the dispensed fuel and the residual tank fuel. The effects of emission controls may also be included in this factor. These more locally specific and up-to-date emission factors are scored higher than the *AP-42* factors.

The most significant difference between the preferred and the first and second alternative methods for this source category is how the activity-level data are collected. The preferred methods for activity data collection use either local gasoline sales data collected by a state or local tax authority, or survey data obtained from gasoline retailers in the area. Using local gasoline sales tax data results in the highest DARS scores for activity attributes. The other preferred method for collecting activity data, a survey of gasoline retailers, will require a scaling step. That scaling step could introduce the same level of variability to the estimate that is introduced in Alternative Method 2, in which state-level gasoline sales are scaled down to the inventory area. DARS scores assigned to the survey approach and the scaled state-level data approach reflect this similarity.

A component of the DARS scoring for gasoline trucks in transit, fuel delivery to outlets, and vehicle refueling is the apportioning of the activity. For trucks in transit, the amount of gasoline sold in the area must be adjusted up to account for gasoline that is transported twice within the inventory area and gasoline that is transported through, but not delivered in, the area. The preferred approach for this adjustment, using weigh-station data, will not capture all of the activity. Activity scores for the preferred method are reduced because of this adjustment approach. The alternative approach is a national default factor, which reduces the spatial congruity score because it will not reflect variability at the local level. The activity temporal congruity score for tank trucks in transit is also lowered since the adjustment factor is based on

a 1978 report on gasoline marketing (EPA, 1991) and does not reflect any recent changes in transport practices. Adjustments for fuel delivery to outlets and vehicle refueling activities must be made to define uncontrolled or controlled portions for the emission estimate. In each case, the apportioning procedure reduces the rating of activity measurement and source specificity from what they might have been if the activity level had been more directly measured and assumptions about the application of controls were more specific to gasoline sales. These adjustments may result in an over- or underestimation of emissions if the assumptions are not valid in the inventory area.

6.1.2 SOURCES OF UNCERTAINTY

Another way to assess the emission estimates is to examine the associated uncertainty. For activity estimates derived from survey data, the uncertainty can be quantified (see Chapter 4 of Volume VI of the EIIP series). Statistics needed to quantify the uncertainty for other methods of activity-level data collection are incomplete.

Sources of uncertainty in estimating emissions from gasoline marketing include the difficulty of collecting information for adjustment and apportioning factors, and the use of assumptions when using that information. Of particular concern is the assumption that activity data for fuel delivery to outlets can be apportioned to different types of controls by a count of gasoline stations with no consideration of the differences in throughput that may exist between a larger and possibly controlled station and a smaller uncontrolled station.

The emission factors provided in *AP-42* also carry a degree of uncertainty in that any single emission factor for gasoline marketing processes will not necessarily reflect the local gasoline formulation or temperatures, or the equipment and handling practices in the area for the inventory time period. The emission factors calculated by the MOBILE model should reduce the uncertainty for the vehicle refueling subcategory emission estimates.

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DATA CODING PROCEDURES

The inventory preparer should check the EPA website (http://www.epa.gov/ttn/chief/) for the latest information (codes) available to characterize emission estimates from gasoline marketing. A complete list of Source Classification Codes (SCC) can be retrieved at http://www.epa.gov/ttn/chief/codes/. Table 11.7-1 lists the applicable SCCs for gasoline marketing.

Available codes and process definitions influence and help guide the preparation of emission estimates for this category. Data transfer formats should be taken into account when an inventory preparer plans for data collection, calculation, and inventory presentation. Consistent categorization and coding will result in greater continuity between emission inventories for use in regional and national scale analyses.

7.1 NECESSARY DATA ELEMENTS

If the category emissions data will be transferred to EPA for incorporation into the national criteria and toxics air pollutant inventory, specific data transfer formats are acceptable. The acceptable data transfer format(s) are described and available for download at http://www.epa.gov/ttn/chief/net/. The acceptable data transfer formats contain the data elements necessary to complete the data set for use in regional or national air quality and human exposure modeling. The inventory preparer should review the area source portion of the acceptable file format(s) to understand the necessary data elements. The EPA describes its use and processing of the data for purposes of completing the national inventory, in its Data Incorporation Plan, also located at http://www.epa.gov/ttn/chief/net/.

TABLE 11.7-1

AREA AND MOBILE SOURCE CATEGORY CODES FOR GASOLINE MARKETING

Process Description	Source Category Codes
Petroleum Product Transit: Truck - Gasoline	25-01-030-120
Petroleum Product: Underground Tank Filling-Submerged	25-01-060-051
Storage - Gasoline Service Stations: Underground Tank Filling-Splash	25-01-060-052
Storage - Gasoline Service Stations: Underground Tank Filling-Balanced Submerged	25-01-060-053
Storage - Gasoline Service Stations: Vehicle Fueling-Uncontrolled Displacement Loss	25-01-060-101
Storage - Gasoline Service Stations: Vehicle Fueling-Controlled Displacement Loss	25-01-060-102
Storage - Gasoline Service Stations: Vehicle Fueling-Spillage	25-01-060-103
Storage - Gasoline Service Stations: Underground Tank-Breathing and Emptying	25-01-060-201
Storage - Gasoline Service Stations: Total All Processes	25-01-060-000

8

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